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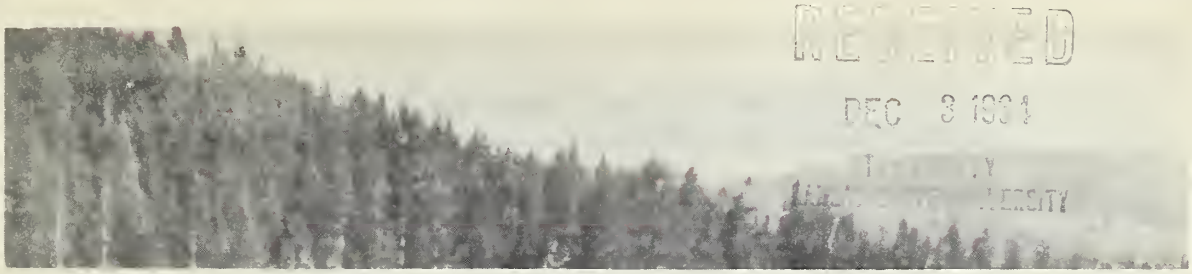

THE MOOSE

And Its Ecology

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FRONTISPIECE: A Montana Bull

Photo by Montana Fish and Game Commission

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THE MOOSE AND ITS ECOLOGY

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INTRODUCTION

The general decline of moose populations has aroused great interest, and numerous popular articles have appeared on the subject. Since 1929, however, no attempt has been made to bring together the information that has been steadily accumulating concerning this important big game animal and its management. With this in mind the author has undertaken the task.

As the moose is an animal difficult to observe, large, and unusual in form and action; it is an ideal subject about which to write unnatural history. Pliny reached the zenith in this in his natural history of the Scandinavian species. He described the animal as having no joints in the hind legs, so it had to lean against

a tree to sleep; and as it was very swift, it could be taken only by partly severing trees which would act as traps when it leaned against them. The upper lip was thought to be so long that the animal was forced to back up while grazing (Grant 1901). 1/ Fortunately modern writing is not so fantastic as this, but much misinformation on the animal has appeared.

DISTRIBUTION AND ECONOMICS

Classification

Three forms of the moose are found in North America. The more common one, Alces americana americana (Clinton), ranges across central and southern Canada and parts of the northern United States from Nova Scotia and Maine to the Yukon River; the Shiras moose, Alces americana shirasi Nelson occurs in the Yellowstone National Park region of Wyoming, in Montana, and Idaho (Hall 1946; Anthony 1928); and Alces americana gigas Miller is found in Alaska. Although known in Europe as the elk, the moose of Scandinavia and other parts of northern Europe, Alces alces alces, is very close in characteristics and habits to the North American moose (Kakies 1936). Another form, Alces alces pfezenmayeri, is found in northern Asia.

Distribution

Early records show that the moose originally ranged in a broad belt across Canada and parts of the northern United States, from Nova Scotia, Maine, and the Adirondack Mountains (with a few animals occurring as far south as northern Pennsylvania) to the western coast of Alaska (Burt 1946). An arm of its range extended down through the Rocky Mountains to northeastern Idaho and northwestern Wyoming. (fig.1)

The present range has been reduced much more in the United States than in Canada. Although Maine still has some moose throughout the State, the bulk of the population is now in the southern half. The New Hampshire Fish and Game Department estimated in 1946 that 40 animals were scattered throughout that State. There are occasional records of individual moose in Vermont and in the Berkshires of Massachusetts (Warfel 1937a and 1937b), probably strays (Crane 1931). None has been reported in the Adirondacks since 1886 (Grant 1894) except for an unsuccessful stocking. In Michigan a few are left in the Upper Peninsula, probably the result of stocking between 1935 and 1937 (Ruhl 1940), and on Isle Royale is one of the largest herds in the country (Hamilton 1943; Burt 1946). Fair numbers occur in Minnesota north of a line drawn northwest from Duluth (Swanson, et al. 1945). A 1947 aerial survey indicated good populations in the Red Lakes area and in the Mud Lake National Wildlife Refuge, but very few in the Northwest Angle and along the International Boundary (Highby 1947).

1/ Publications referred to parenthetically by date are listed in the Bibliography, pp. 44-51.

Figure 1.--Original distribution of the moose of North America (Burt 1946).

The occupied range seems to be increasing in the Rocky Mountains. For a decade Montana has reported consistent population gains, and Idaho has had an increase in moose over the same period. The Wyoming herd has held rather constant since 1937. A few animals have been reported from northeastern Washington (Scheffer and Dalquest 1944; Dalquest 1948).

In general, it seems that the moose in the New England States and the Great Lakes States (with the exception of Isle Royale in Michigan) are increasing at a slower rate than those in the Rockies. The Maine herd is thought to be increasing satisfactorily, however.

The exact limits of distribution in Canada and Alaska are not known so definitely as in the United States, but the large moose ranges are in these northern areas and their extent is approximately that of the original distribution. The range is reported to be extending northward in the MacKenzie River area in northeastern Manitoba (Anderson 1924) and also in northern British Columbia (Brooks 1926; Swarth 1936).

Numbers

Seton estimated the original range of the North American moose to have been 3,500,000 square miles and the primitive population 1,000,000.

Present population estimates are more thoroughly grounded. In 1941 the total moose in the United States were estimated at 11,840 (Jackson 1944), and by 1946 this was thought to have increased to about 18,700 (Anon. 1948). Moose in Alaska were estimated to number 30,000 in 1946 (Dufresne 1946). The number in Canada is conjectural; however, if a population density equal to that of the United States and Alaska is assumed, Canada with about three-fourths of the total range would have 146,000 moose. This would make the North American total an estimated 195,000.

Values

The economic and aesthetic values of the moose are difficult to determine; the more impressive is, perhaps, the aesthetic, resulting from the thrill of seeing such an unusual and magnificent animal.

The economic value of the Alaskan moose has been calculated in several ways. The annual surplus from a basic herd of 1,000 animals, using a meat value of only 20 cents a pound and average weight of 800 to 1,000 pounds, would be worth from $37,000 to $45,500. Trophy values would easily bring this to $50,000 a year. Tanned moose hides were worth $14 to $18 apiece when tanning cost $5 a hide. Actually, the total value of each moose taken out by nonresident hunters is many times the meat value. However, a good-sized moose was considered

a winter meat supply for three or four people. 2/ In 1922 Chicanot (1923) estimated that nonresident moose hunters spent $2,000,000 a year in Canada for licenses, railroad fares, and other expenses. This sum was based on an estimated 10,000 hunters.

Within the continental United States only three States--Idaho, Montana and Wyoming--have had recent open seasons on moose, and these were all on a special permit basis.

LIFE HISTORY

Because of their wariness and the comparatively small number of animals available for study, some of the details in the life history of the moose are still not settled. However, quite a complete story now can be written.

The first indication of the start of the active reproductive cycle is the rubbing of the velvet from the newly-grown antlers. The removal takes from 8 to 10 days (Murie 1934). Records from the Eastern and Lake States show that most antlers are cleaned by early September (Merrill 1916; Murie 1934; Kellum 1941). In Yellowstone National Park; however, Bailey found that on October 1, not more than half the bulls had removed all the velvet from their antlers.

With the completion of the antler-polishing the bulls are ready to fight for mates and the rut begins. It seems to start quite uniformly throughout the country in early September and continues into October. A few matings undoubtedly occur in November. On the basis of experimental reindeer studies, Palmer has suggested that a good food supply may advance the onset of the rut and a poor one retard it. 3/ During this period the cows stay in a rather limited territory; the bulls travel widely, even neglecting to feed, and losing up to 150 pounds in weight (Kellum 1941). Although all the animals are in excellent condition at the beginning, the bulls are gaunt by the end of the breeding season. 2/ During the mating season a bull usually remains with a single cow and her calf for a week or ten days and then leaves to seek another cow. Observations in Alaska showed that during the early part of the breeding season mixed groups of both sexes were usual. Then, for about three weeks 1 or 2 bulls and several cows stayed in a group, and yearlings and lone bulls were usually found elsewhere. Later, the mixed groups form again.

2/ Palmer, L. J. 1938, Kenai Peninsula Moose. Alaska Research Project Report, Sept.-Oct., Fish and Wildlife Service, pp. 1-27 (Not available for distribution).

3/ Palmer, L. J. 1933, Range reconnaissance Kenai Peninsula moose area, July, Fish and Wildlife Service pp. 1-11, (Not available for distribution).

Palmer 2/ reported that the rutting animals are almost invaribly in or near clumps of spruce or alder, but rarely out in the more open willow or aspen stands. The cows are said by Seton (1929) to do most of the calling, while the bulls listen and travel. Palmer, however, found both cows and bulls calling. 2/ Calling is more common in the East, some believe, but the fact that from Maine to Alaska bulls can be called up with birch bark horns seems to indicate the universality of this behavior.

Some have contended that the animals are monogamous, but the evidence points to a limited type of polygamy (Murie 1934; Cahalane 1947). Instances have been noted of two to four cows with a bull at one time, but no real harems were built up (Burt 1946; 2/). A preponderance of cows resulting from the killing of bulls does not in itself seem to produce barrenness in the cows (Merrill 1916), as it is believed that a mature bull can serve up to a dozen cows per season. 4/ Even limited hunting, however, appeared to disturb rutting animals in Alaska, and cause them to move out of an area where they had congregated. The mature bull apparently takes no notice of the calves of the year. Young bulls are simply kept at a distance from the cows by the old bulls until they are 3 years old, and even then they are ordinarily not able to mate, because the older bulls fight them off (Seton 1929).

The mortality from battles between bulls during the breeding season is significant. In traveling 450 miles in Alaska, Dufresne found the locations where 7 pairs of bulls had fought to the death. There were three instances of locked antlers and in the other four cases the skulls were a few yards apart. 5/ The bulls often paw the ground and rip it up with their antlers (Murie 1934). Palmer noted that there were often two holes 6 to 8 feet apart, apparently made by two bulls face to face.

The call of the moose is seldom heard except during the rut. This call is subdued but clear at distances up to 200 yards. Palmer described the call of the bull as ".....either a low, moo-like plea broke off short with an upward inflection at the end, or a throaty gulp." He said the call of the cow was ".....longer and more like that of the domestic cow, but not nearly as loud," and that of the calf ".....similar to that of the domestic cattle with a moo-like beginning, and ending in a petulant bawl." 2/ The call of the cow to her calf was described as a single grunt frequently repeated. 6/

4/ Cooney, Robert M. 1943, Montana moose survey, Hellroaring-Buffalo-Slough Creek Unit. Wildlife Restoration Division Report, Montana Fish and Game Dept., pp. 1-70, (Typed).

5/ Dufresne, Frank 1933, The Kenai Peninsula moose herds. Report of the Second Special Investigation, May 30 to July 19. Fish and Wildlife Service, pp. 1-16, (Not available for distribution).

6/ Palmer, L. J. 1939, Kenai Peninsula Moose, Alaska Research Project Report. May, June, July Fish and Wildlife Service, pp. 1-33, (Not available for distribution).

In earlier accounts the writers attempted to relate the making of wallows to mating (Seton 1929; Merrill 1916). No real use of these was recorded, however, until September 25, 1947, in the Absaroka area of Montana, when a bull was seen repeatedly pawing up a patch of ground and urinating in it. As a cow approached, the bull rolled in the mud, apparently trying to get as much as possible on him. The cow drove him out and wallowed, but the bull returned, drove her out, and wallowed again. Subsequent actions indicated this wallowing to be a premating activity, although mating was not observed. The wallow was circular, about 36 inches in diameter, 8 inches deep and had a musky odor. Two other wallows were located 30 and 50 yards away respectively. 7/

Captive moose in Michigan were observed to wallow in a mill pond during hot summer weather. The animals would lie for hours with only part of the head above the mud and water. (Kellum 1941).

Although there seem to be no exact records to confirm it, the gestation period is considered to be about 8 months (Murie 1934; Kellum 1941) or according to Seton (1929), 242 to 246 days.

Palmer 6,8/ found in Alaska that, beginning in early April the cows and bulls separate. The cows return to their favorite calving grounds, and the bulls form groups and tend to move to the higher ranges. Toward the end of June, following the birth of the young, the cows and calves also move up to the higher ranges.

It appears to be well established that very few calves are born in April throughout the moose range. Most of them arrive in May and some in June (Hickie undated; Merrill 1916; Cahalane 1947; Murie 1934 and 1944; Dufresne 1942; Manweiler 1941; Seton 1929). In the spring of 1947 the first calf was found May 31 on Isle Royale, Michigan; in 1946, on May 21. On the Gallatin moose range, Montana, cows were calving near the open slopes in late June and early July. 9/ The calves were born from about May 25 to June 20 on the Kenai Peninsula moose range in Alaska. 5,8,6/

One or two young are produced at birth. It is believed that rarely there may be triplets. The percentage of cows bearing twins seems to vary widely in different areas, suggesting less twinning with poorer range conditions. In the Mount McKinley National Park,

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7/ Gaab, J. E. 1948, Absaroka Unit moose survey. Wildlife Restoration Report, Montana Fish and Game Dept., pp. 61-76, (Multilithed).

8/ Palmer, L. J. 1938,Management of moose herd on Kenai Peninsula, Research Project Report, Mar., Apr., and May, Fish and Wildlife Service, pp. 1-40, (Not available for distribution.).

9/ Gaab, J. E. 1948, Gallatin unit moose survey, Wildlife Restoration Division Report. Montana Fish and Game Dept., pp. 77-94, (Multilithed.).

Alaska, 9 cows were observed with single calves and 7 with twins — (Murie 1944). On the Kenai National Moose Range, Alaska, a total of 142 calves counted at 5 different times showed that the ratio of cows with single calves to those with twins ranged from 1:1 to 10:1. The ratio increased from 2:1 in early June 1939 to 8:1 during the last half of the month. 2,5,6/ Forty-seven single calves and 3 sets of twins were observed in Isle Royale National Park, when the moose population was high (Murie 1934). Bailey (1930) saw so many cows with twin calves in the Yellowstone National Park that twins seemed to be the rule there, rather than the exception. It was reported that of 252 pregnant cows killed in an open season in eastern Canada, only 21 (8 percent) had twin foetuses. (Murie 1934).

Experience with captive moose has shown that the first pregnancy ordinarily results in the birth of a single calf. When twins are born, the young mother lacks enough milk for both and usually abandons one of them (Stott 1948).

The Alaskan moose mother attempts to protect her newborn calf. Adolph Murie (1944) reported that a cow with a calf was attacked by two husky dogs, but she drove them off. Dufresne (1946) stated that the cow will guard her young from a human invader, her mane bristling and ears laid back; (fig. 2), not even a bull in the rut

Figure 2.-- The cow moose guards her calf well
Photo by Montana Fish and Game Commission

commanding greater respect. In at least one case, a man was "treed" by a cow moose in Minnesota; presumably she had a calf nearby. In Alaska a guide and his young son were attacked by a cow with a calf. 5/ Observations in Montana suggest that the cow moose has a stronger parental instinct than the cow elk. Of 19 moose calves observed, 18 were either at the mother's side or she was close by. It has been found that the cows, when protecting their calves, will attack a man on foot or on horseback. If the calf is too small to travel, the cow will stand her ground, allow an approach to about 20 yards from the calf; and then charge, striking with both front feet if a closer approach is made. 9/

The calf is awkward, wobbly, and rather helpless during the first day or two following birth; and when it first begins traveling, it is likely to stumble over logs or get caught in the brush, expecially if frightened. 6/ The youngster is able to swim with the mother while still very young (Merrill 1916; 6/). When found by man, the calf can be approached easily and will often follow after being petted (Merrill 1916). When alarmed, however, a calf a few days old can outrun a man (Kellum 1941).

Cows with calves prefer shaded creek bottoms, tangled swamps, and "sequestered brushy patches". They are continually on the alert, quickly scent danger, and flee from it. This is thought to be a factor in summer counts. 5/ In Maine most cows with calves are found near water (Dyer 1948).

The calves grow rapidly. At birth they weigh 25 to 35 pounds and gain 1 to 2 pounds a day the first month, and 3 to 5 pounds daily the second month (Kellum 1941). A 6-weeks-old calf is of about the same height as a mature, white-tailed deer buck (Merrill 1916). A year-old bull weighs 400 to 600 pounds; a 2-year-old about 700 pounds; and a 3-year-old 900 pounds. After the first 3 years, growth is slower. The cows weigh about 400 pounds at 1 year of age, 600 pounds at 2 years and 600 to 800 pounds at maturity (Kellum 1941).

Although a rather wide range of weights for mature moose is recorded in the literature, few of the animals have actually been weighed. Weighing a big bull is no mean accomplishment under favorable conditions, and animals are killed too far in the bush for even an attempt to weigh the whole carcass. Seton (1929) reported the weight of dressed meat from an animal 6 feet high at the withers as 500 pounds, thus giving an estimated live weight of 900 pounds. Other dressed weights recorded by Seton indicated a live weight of 1,100 pounds for a "fair-sized bull moose of about 5 years old" from the "Kippewa country"; of about 1,300 pounds for one Maine animal, and of more than 1,400 pounds for another from that State; and of 1,600 pounds for a Quebec specimen. He estimated Alaskan and Yukon bulls to weigh up to 1,700 or 1,800 pounds. A bull thought to be 5 or 6 years old killed in Minnesota weighed 1,056 pounds live weight and 800 pounds hog-dressed (Breckenridge 1946).

Most authorities agree that weaning takes place about the time the next calf is born (Merrill 1916; Murie 1934; Roosevelt 1924; Burt 1946; Cahalane 1947). Cooney, however, reported that in Montana weaning begins in December. 4/

Dufresne described the yearlings as the "orphans of the herd". They like to be with the older animals but are often met with bristling manes and snapping teeth. Cows heavy with calf often show extreme annoyance when their yearlings persist in following them, but cows not pregnant allow the yearlings to continue with them. 5/

Rate of Reproduction

Although no actual figures seem to be available on the rate of increase, there is a general assumption that barren, mature cows are common. Studies in Minnesota indicated that 20 percent of the cows were barren. Manweiler (1941) and Murie (1934), working on Isle Royale during a peak moose population, estimated that not more than half of the cows over one year old had calves.

As to the actual rate of herd increase, we have Seton's estimate of not more than one-fifth of the herd per year. This agrees with the Montana report that the calf crop in a herd of 165 animals was 18 percent. 9/

Although few exact data are available on the maximum age attained, Merrill (1916) believed the animals may live to be 18 to 20 years old. Palmer writes of an Alaskan bull that appeared at a camp as a calf and came back each year for 15 years. 6/

The bull calf develops horn "buttons" with caps on them, which are rubbed off during the latter part of the first winter. The antlers of the yearling are spikes up to 6 or 8 inches long. The second set is crotched; at three years of age the young bull develops small palms on the antlers, each having about three points. The 4-year-old has the adult antler form, but the set is still small. At about 7 years the bull is in his prime, and his antlers are best developed from 6 to 10 years of age (Kellum 1941; Merrill 1916). Past this period, the antlers weight may be less and the beam larger than in younger animals. (Manweiler 1941).

The largest heads come from Alaska where the greatest antler spread on record is 77 5/8 inches. (fig. 3) The largest record from Canada is 73 inches, from Minnesota 54 inches, and from Wyoming 53 1/4 inches (Ely, et al. 1939).

The 2-year-old sheds his antlers in April and they are dropped earlier each year following until, in the prime of life, they are lost by late December or early January. The new set begins to show in April and growth is completed in about three months.

Figure 3.--Alaskan bulls have some record antlers.
Photo by E. P. Walker

CHARACTERISTICS AFFECTING MANAGEMENT

Senses

Although under some conditions, moose may not show alarm when approached by humans, their warning faculties are good. Where they are hunted, few moose are observed, which have not already located the observer. Their sense of sight appears to be rather poor, since a motionless man downwind seems to cause little concern. However, when a person is seen in motion, the moose is likely to circle downwind, where he can better analyze the situation by means of his very sensitive nose. The sense of hearing is also acute (Kellum 1941; Merrill 1916; Seton 1929; Murie 1934). 4,5/ Lamson (1941) found that a captive Maine moose detected people approaching from the leeward 1½ to 3 minutes before the observer could hear their voices or footfalls. Yearlings are frequently curious and usually are easier to approach than older animals.

The moose is a strong swimmer (fig. 4) and evidently can swim for miles at a fair rate of speed (Merrill 1916; Roosevelt 1924; Sheldon 1936). When once started on a "cruise" the moose seems to stick to its purpose much more strongly than deer. When its course is cut off by a boat, a moose is likely to mill around and, when the boat is out of the way, resume swimming in the original direction.

Figure 4.--The moose is a strong swimmer

When disturbed, the moose is likely to analyze the situation before becoming alarmed. If an unusual sound is heard, it usually looks intently in that direction for some time. When convinced that there is need for alarm, it starts away gradually picking up speed to a swinging trot, which covers ground at a fair rate.

The moose is a particularly easy subject to accuse of an "attack" on humans. Its size alone makes even close proximity seem dangerous; and after a close encounter, the details in a person's mind are apt to be colored by fear. The expression of a bull, or

even a cow, staring at the observer is also anything but reassuring. Many "attacks" have been caused by a moose chasing a dog retreating toward its master. The bull in rut or the cow with a calf may show fight. Also, cases have been recorded in which continued aggravation caused the animal to charge (Manweiler 1941).

The actions of moose in summer often indicate that they are plagued by biting insects. Toward evening Palmer observed a cow dash out of the woods and into the water where for 20 minutes, she raced in circles, bucked, "sunfished," and all but stood on her head to splash water on herself and get rid of the mosquitoes. "With ears laid back she was a picture of frantic rage." After calming down, she stood in the water for a long while. 6/

Moose calves are easily tamed. When they grow up, however, they often become unmanageable particularly during the breeding season (Hawkins 1911: Ray 1948). Seton mentioned that he had seen several moose that had been broken to harness. He considered them better draft animals than reindeer for the country where they were native.

Social Habits

The moose is not a herding animal in the usual sense; even at licks and in lakes the individuals move independently. In winter, solitary animals are found while others are "yarded". In other words, the moose seems to enjoy a moderate amount of companionship, regardless of sex, most of the year; yet the gregarious instinct is feeble.

Populations

The make-up of a given herd as to sex and age depends on a number of factors, as food supply, predation, weather, and hunting. In the Kenai area, Alaska, where there is a fairly heavy kill of both bulls and cows, three observers obtained suprisingly consistent results from fall counts over a period of 7 years.

TABLE 1.-- Fall herd classifications, Kenai Peninsula, Alaska

Year	Bulls	Cows	Yearlings	Calves	Undet.	Animals Counted
			Percentages			
1932	40	41	(?)	12	7	1/ 521
1933	50	34	7	9	-	1/ 520
1938	41	41	11	7	-	2/ 266

1/ See footnote 5 p. 5. 2/ See footnote 2 p. 4.

Maximum population numbers of moose are low when compared with those for deer.

On Isle Royale, Michigan, where probably the most intensive work has been done with moose populations, Krefting 10/ found in an airplane strip count that the greatest density was three per square mile. However, at the time of the previous peak population, an estimate of 13 moose per square mile was made (Titus 1941).

A Minnesota aerial survey 11/ made in late January 1947, showed 206 moose on 803 square miles in the Red Lakes area; 17 on 20 square miles at the Mud Lake Refuge; in the Northwest Angle 2 were observed in 66 square miles; and 4 were seen in 270 square miles, along the International Boundary.

In the Kenai Moose Range of Alaska estimates for relatively small areas were given as 1.5 to 2.0 per square mile in 1933 and from 2.2 to 3.7 in 1938. There was an estimated average of 1.2 per square mile over an 850 square mile area. 2,5/

On St. Ignace, a wooded island in Lake Superior, Ontario, Seton stated that the food supply failed when a moose population of ten animals per square mile was reached. He considered four to the square mile the maximum number for safety (Seton 1929).

Over large areas, with no barriers to movement, one moose per square mile can probably be regarded as a good population.

So little is known of moose numbers and movements that there is a question as to whether the highs and lows of populations in a given area are caused by cycles or migrations. It is an accepted fact that in given areas moose have periods of scarcity and abundance. Whatever the cause, there seem to be several authentic records where many moose were present, disappeared and reappeared.

One of the best indications of cycles is found in the 39-year record of moose killed in Sweden. Starting with a low of 800 in 1901, the kill reached a level just below 3,000 in 1909 and maintained it until 1916. It declined rather evenly to a low of 500 in 1923, and then climbed steadily to 8,900 in 1939 (Wenmark 1938; Anon. 1940). However, since these kill figures are simply given as yearly reports, there is no indication of the possible effects of seasons, weather, regional variations, or unknown factors.

10/ Krefting, Laurits W., Airplane count of the Moose on Isle Royale National Park. Special Report, Fish and Wildlife Service, pp. 1-5,1947 (Not available for distribution).

11/ Highby, Paul R. 1947 , Quarterly progress report, Wildlife Restoration and Management Planning Project, 11-R, Minnesota. Division of Fish and Game, pp. 9-11.

The same holds true for the available figures from Norway (Salvesen 1939) (fig. 5). In any event, the kill figures declined from

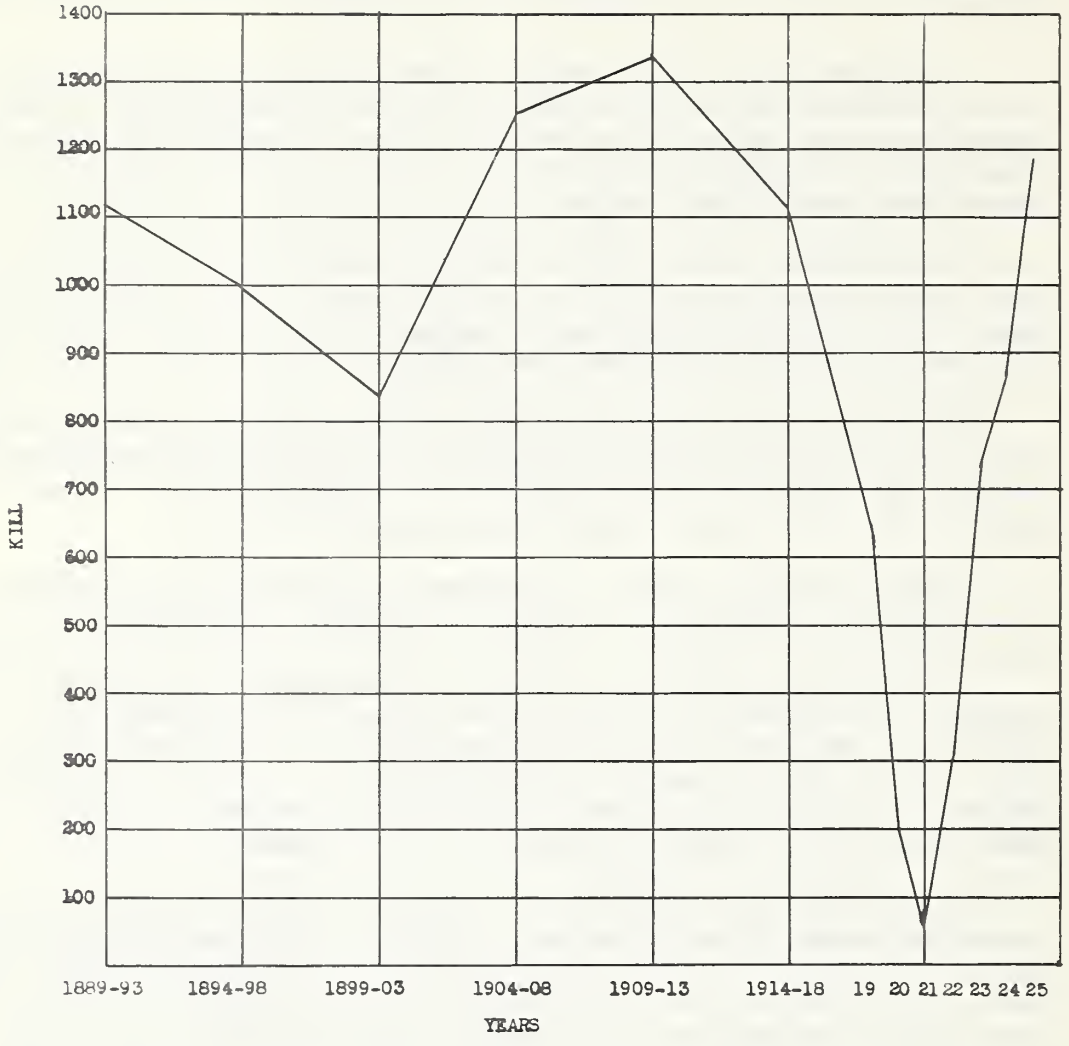

Figure 5.-- Yearly kill of moose in Norway (Salvesen, 1929)

1,120 in 1889 to 839 in 1900. A peak kill of 1,338 was reached by 1911, after which there was a sharp decline to 57 in 1921 and a quick rise to 1,186 in 1925. This big decline corresponds roughly to the one in Sweden. The author mentioned that protection may be complete in some sections; only bulls may be killed in some places; and that, in 1925, a kill of 74 animals was allowed in State Forests. He also said that "From time to time the moose is over-hunted in some districts, but after a few years' protection they come back again." To determine how significant these figures are from a cyclic standpoint would require further investigation, however.

In the Skilak Lake area (Kenai Peninsula), Alaska, in 1898 a gold mining expedition was able to kill only one moose during the winter, but by 1907-08 the species had become quite plentiful, and a peak population occurred in 1913. The rabbits reached a peak the following year, and their hordes devoured the willows. The following spring carcasses of moose dotted the country. In 1920 another peak moose population was reached. Since then the numbers had lessened, and it was suggested that the animals may have moved to better feeding grounds. 5/

Sheldon (1936) reported that around Lake Kedgemakooge, Nova Scotia, moose increased over a period of 35 to 40 years, but since 1922 had apparently sharply decreased. This was thought to be a die-off.

Movements

While some moose may be observed feeding at any time of the day, the greatest activity occurs near dawn and dusk (Lockhart 1890; McCabe and McCabe 1928; East 1932; Murie 1934; Lamson 1941; Burt 1946).

When undisturbed, the animals ordinarily do not move far throughout the day. They may go down from the uplands to the water to feed on aquatic plants, or they may travel to a favorite willow thicket for food or cover. The distances involved, however, are usually short. During early summer the animals tend to feed throughout the day. Later, as they become fat, they lie down during the heat of the day, coming out to feed in the late afternoon. 4,5/ Much of their movement in summer is at night. 6/

Seasonal movements of moose are generally limited to comparatively short distances. They seem to be governed by availability and palatability of food more than by topography, as such (Hickie 1938). Depth of snow and the resulting effect on food availability often determine the location of moose in winter. On Isle Royale, for instance, the better food supplies of balsam are on lower ground, but the ridges have less snow, so in late winter, moose are sometimes scattered over the ridges (Murie 1934). At other times they concentrate on low ground. 10/

In Maine, where snow depths of 8 to 10 feet are reached, there is a great variation in the seasonal movements of moose. Many stay in the same general locality the year around. Following the rut the animals tend to assemble in small, family groups and move into areas of abundant browse. Some groups yard at low elevations. As snow accumulates in November, others move up to yarding areas at altitudes ranging from 2,500 feet to near the mountain summits (4,000 to 5,000 feet). Still others do not yard at all. In 6 of the 18 yards studied, moose and deer were found together. Feeding during winter was heavy over small areas with some movement out as food became scarce.

The animals from the high altitude yards moved down in April as the snow receded, usually traveling considerable distances to the summer range. In yarding, the animals showed a decided preference for old growth stands along blowdowns, for recent cuttings where sprout growth was available, or areas near ridges where mountain maple, striped maple and mountain ash were abundant. Swamps with plentiful food were also used. (Dyer 1948).

The moose in Yellowstone National Park are at lower elevations in summer and go higher in late September. Many of the high meadows here have springs and swamps which never freeze, and in which the moose can feed in winter. They come down again in late April or early May (Bauman 1941). Cooney 4/ found no general seasonal migrations from summer to winter range in the Absaroka National Forest, Montana; rather, there were several local movements within the range. In June the animals were in or near the lower meadows; in July and August they scattered and moved to high country where there was more succulent vegetation and greater protection from insects. During September the lowlands were again heavily used. Then around the end of the month when frosts had killed the willow (Salix) leaves, which are preferred to the browse, the moose returned to the timbered slopes. There was another movement back to the lowlands in November and December, and willow browse became the main food. Later, when the willows were all eaten or snow became too deep for feeding, the moose returned to the ridges. Obviously, palatability and availability of food governed these movements. Most observations showed that the animals' summer and winter ranges were in the same drainage. 9/

Hatter (1946), described a "characteristic" winter migration at Ootsa Lake in British Columbia. He thought the moose might travel 50 to 60 miles from summer range to wintering grounds. Palmer records an Alaskan winter migration (1921-22) in which "as many as 150 moose in close formation " were observed heading up over a high divide. Many animals died among the rocks of the ridge, for there was a food shortage in the area abandoned by the moose. In this range the moose normally migrated down from the high ridges with the first snow. During the fall the animals were widely dispersed over the lower country. Winter and spring found them from the coast up to elevations of about 1,000 feet above sea level; occasionally they reached 3,000 feet. The summer range was at the higher elevations from 1,000 feet to the divides. 2,8/

Yarding seems to be much less necessary and more indefinite with moose than with deer. Hickie (undated) found the Isle Royale animals to "yard" in late winter. However, he found that they do not stay closely yarded. Cahalane (1947) stated that they use swamps as winter headquarters and range over the ridges. Seton (1929) thought that all sexes and ages might yard together, although the old bulls were more likely to stay alone. He stated that if food in a yard gave out, the animals migrated in single file looking for more forage. In Montana, Cooney 4/ recorded little or no tendency to yard, and the animals fed at random in creek bottoms and on slopes and ridges. It was thought

this was perhaps due to a scarcity of willows. 4/ In British Columbia, Minnesota, and Mt. McKinley Park, Alaska, true yarding was unknown (McCabe and McCabe 1928; Swanson, et al. 1945; Manweiler 1941; Murie 1944).

There seems to be a fairly general belief that moose may disappear from an area, then after a long period, reappear. The causes of the disappearance are perhaps varied and certainly not determined. Early writers blamed settlement and lumbering for the exodus. However, in some cases, moose have become scarcer in areas with thin human populations and have increased in cut-over lands, where there are many more people. An instance of this is found in the State of Maine. Following settlement inland from the coast, moose were eliminated from all but the northern counties by 1904. By 1941 they were rare in the northern and western parts of the State, but common in the southern half (Aldous and Mendall 1941). It is thought that the animals move into new areas in Montana, when populations become high and ranges depleted. 9/

There were only vague stories among the Indians of moose occurring in the Bowron Lake Reserve, British Columbia, a century ago. McLeod, a Hudson's Bay Company trader, found none there in 1861, although there had always been moose 50 to 100 miles to the north. By 1904, moose sign was found 40 miles below Bowron on the Bowron River. Despite heavy toll from hunters, a period of great moose abundance was reached in 1913-14. The peak came about 1922.

In this area settlement had helped the moose to build up their populations. In the early days the native culture depended on hides, and moose skins by the thousand were handled by the Hudson's Bay Company at Stuart Lake, British Columbia. They were used for clothing, window coverings, saddle bags, and horse and dog harnesses. Many of the skins used were from calves. As the white man took over the region, the Indians were reduced in numbers, and later, an epidemic eliminated them from a large area. This allowed the moose to increase and gradually move into the region. To quote the writer, this "indicates some slow and unconscious outward pressure such as might result from the removal of some natural or artificial check on the rate of breeding or the average of survival." (McCabe and McCabe 1928).

Farther west the 54th parallel was the southern boundary of the moose range except for occasional stragglers until about 1850. Then, following settlement, the range has extended practically to the United States boundary around Squamish and Princeton, British Columbia. (Hatter 1946). In the Absaroka primitive area, Montana, a moose was rarely seen from 1907-1915. By 1921 it was estimated that there were 25 in the Absaroka National Forest, and by 1936 these had increased to 308. 4/ On the Gaspe Peninsula in Quebec, the last interval between the moose leaving and returning was about 50 years. In the area between the upper Great Lakes and James Bay the interval was longer.

Then there is the theory that moose succeeded caribou on much of their original range, following logging and fire. Later, deer seem to have taken over the same areas (Swanson, et al. 1945; Surber 1940). In one case, in British Columbia, moose have come in during the past 100 years and have greatly increased. At the same time, caribou have held their own and mule deer have increased tenfold (Brooks 1926).

Writing of his first trip to Lake Superior in 1870, Shiras 4/ said he found moose practically unknown along its northern or southern shores; the same was true of a large area north of Lake Huron. The greater part of western Ontario was occupied by caribou. This later became some of the best moose range. Hickie (undated) found that caribou were more plentiful than moose around the western end of Lake Superior until about 1900. Then moose increased until 1928, after which they decreased and were soon outnumbered by deer.

Ordinary travel conditions seem to have little effect on moose, even deep mud having no terrors for them. While wallowing through it they may become tired and stop to rest, but they do not get panicky and soon struggle on again. Weak animals occasionally die in deep mud, however. (Murie 1934).

Snow deep enough to bother cattle is no hindrance to a moose (Merrill 1916; Newsom 1937a).

There was an early belief that a moose would not go on ice if it possibly could be avoided (Merrill 1916). However, in British Columbia tracks were repeatedly found on ice where moose were breaking into muskrat houses. West of the Fraser River this habit was said to cause frequent complaints from fur farmers (McCabe and McCabe 1928). Newsom (1937a) also reported having found places where moose had crossed lakes on ice.

Foods and Feeding

Methods of Feeding

The moose cannot feed easily on low-growing vegetation; however, it does eat plants growing close to ground level by getting down on its knees (Anthony, et al. 1937; Cahalane 1947; Murie 1934; Roosevelt 1924). Kellum (1941) found that to reach the bark on a six-inch log lying on the ground, moose had to kneel.

In summer moose prefer to strip leaves from woody plants rather than to take whole stems, although some stems are taken. In stripping leaves, the animal grasps the stem with its tongue and pulls the leaves off with an upward jerk of the head (McCabe and McCabe 1928; 4/).

The usual method of feeding in winter is browsing on coniferous or hardwood twigs, and those up to the size of a man's thumb are taken (Merrill 1916). A large animal can reach 8 to 9 feet above ground and, by standing on its hind legs, to 12 feet (Cahalane 1947; Roosevelt 1924; 4/). In winter feeding trees are "ridden down" by

the moose straddling them between the forelegs and often breaking them so the tops can be browsed (Cahalane 1947; Merrill 1916). In this manner balsams (Abies balsamea) are sometimes snapped off at a point where they are 2½ inches in diameter. Moose commonly paw through a foot of snow to feed and they are reported to dig down as much as three feet. 8/

The amount of food necessary to winter a moose is considerable. In order to determine the quantity supplied by a representative area in Michigan, Hickie (1937) selected a birch-poplar-balsam stand, with about 1,000 trees per acre, and averaging three inches in diameter, breast-high. The trees were cut and the browse removed. It weighed 3 3/4 tons and captive moose utilized 2 tons of it at a rate of 25 pounds per moose per day. This represents 160 potential moose-days of feeding per acre. Kellum (1941) working with moose in pens, found that they daily ate 40 to 50 pounds of browse in winter and 50 to 60 pounds in summer.

Moose eat the bark from the stems of green poplar trees, which have broken over and lie within reach (fig. 6). The bark is sometimes

Figure 6.--Felled aspen partially barked by moose.

taken from stems 8 to 10 inches in diameter. Kellum (1941) thought that this occurred by choice, especially in spring. Murie (1934) considered the heavy feeding on the bark of mountain ash (Sorbus americana), poplar (Populus sp.), and fire cherry (Prunus pennsylvanica) during May and early June to show a preference for this type of food,

but that winter use of bark indicated starvation. Stephenson 12/ noted extensive barking of the above named trees, as well as willows, alder, and other species at the time of peak moose population. Where mountain ash is available on Isle Royale, it is often barked while standing, sometimes killing the trees. Krefting and Lee found in 1948 that standing poplars were also barked during periods of peak moose populations. 10,13/ Where the moose population was of medium density in Maine, it was found that sapling balsams were commonly barked in high altitude yards. Extensive barking of large stems of mountain ash, striped maple (Acer pennsylvanicum), shad bush, (Amelanchier bartramiana), fire cherry, red maple (Acer rubrum), and aspen occurred in fall and spring and to a lesser degree during winter (Dyer 1948).

Water plants are taken in quantity in summer, and for that matter, in fall. The feeding is done by wading or diving in water up to about ten feet in depth.

Food Plants

East

Moose of the eastern part of the country have quite different and more varied food habits than those of the West. Also, in the East the food taken by moose is quite different from that of deer. Northern white cedar (Thuja occidentalis) is a favorite winter food of deer in the Northeast and is a satisfactory winter browse. Balsam, on the other hand, is almost worthless as a winter deer food (Maynard, et al. 1935). The moose turns to northern white cedar only as a last resort, but seems to winter successfully on balsam.

Careful studies have been made of both winter and summer use of foods on Isle Royale, where the greatest moose concentration in the eastern United States exists. Here some of the more favored foods have been practically eliminated, so that the actual use must be contrasted with availability to be significant.

This island, which at the closest point lies 13 miles off the Canadian shore, is covered with a northern forest type of vegetation. About $\frac{1}{4}$ of the island was burned over in 1936 resulting in young stands of aspen, paper birch, and other deciduous species, where there were formerly mainly conifers.

12/ Stephenson, J. H. 1931, Report of Isle Royale Trip, Sept. Dept. of Conservation, State of Michigan, 3 pp. unpub. (Not available for distribution).

13/ Krefting, Laurits W. and Forrest B. Lee 1948, Progress Report, Moose browse investigations on Isle Royale National Park, May. Fish and Wildlife Service. pp. 1-34 (Not available for distribution).

Winter Foods

Aldous and Krefting (1946), in surveying winter browsing where there were at least 2 moose to a square mile, used 689 one-hundredth-acre sample plots well distributed over the range. They found that the 12 most important foods made up 95.5 percent of the winter use. Table 2 (Page 22) gives the percentages in which the more important moose foods were available and were taken, and a factor (use percent divided by availability percent) which tends to indicate relative palatability. This palatability factor was computed by the writer. The 1948 figures are from Krefting and Lee and are based on 1,166 plots. 13/

Comparison of the outlying unbrowsed islands with the main island and of conditions in 1945, when there were approximately 500 moose on the island, and 1948 with an estimated 1,200 animals, provides some interesting feeding trends. Ground hemlock was the most sought after species and on the main island was reduced to an unimportant position as a source of food long before other species were heavily browsed. It does not recover readily from browsing. Apparently aspen was the next species to rank as the most important food, following the last die-off of moose about 1932. Large quantities of young plants became available as a result of the 1936 fire. This plant rated as number one in use in 1945; however, it lacks the ability to withstand heavy browsing, and by 1948 many plants were dead or dying, and the species was fifth in use percentage (fig. 7). Paper birch, which is only

Figure 7.--Aspen heavily overbrowsed.

TABLE 2.-- Comparison of availability and use of the more important winter moose foods in Isle Royale National Park

More important species in order of decreasing use:	Percentage of availability 1/		Percentage of use 2/		Palatability factor 3/	
	1945	1948	1945	1948	1945	1948
Aspen, Populus tremuloides	8.7	5.4	16.9	9.0	1.9	1.7
Paper birch, Betula papyrifera	9.8	13.2	14.9	15.6	1.5	1.2
Balsam, Abies balsamea	8.6	13.5	13.6	21.8	1.6	1.6
Mountain ash, Sorbus americana	6.8	6.6	12.1	11.6	1.8	1.8
Willow, Salix spp.	5.1	5.1	9.6	7.8	1.9	1.5
Red-osier dogwood, Cornus stolonifera	5.6	4.2	8.3	6.7	1.5	1.6
Ground hemlock, Taxus canadensis	5.5	4.2	4.0	5.1	.7	1.2
Shadbush, Amelanchier bartramiana	2.2	.9	2.9	1.1	1.3	1.2
Fire cherry, Prunus pennsylvanica	2.5	1.8	2.7	1.9	1.1	1.1
Hard maple, Acer saccharum	7.0	9.9	2.7	2.8	.4	.3
Hazel, Corylus cornuta	4.0	4.2	2.5	2.6	.6	.6
Mountain maple, Acer spicatum	5.0	4.5	2.3	3.3	.5	.7
Mountain alder, Alnus crispa	2.4	2.1	1.7	1.7	.7	.8
Sumach, Rhus glabra	.5	-	1.3	-	2.6	-
Balsam poplar, Populus balsamifera	.6	.3	1.0	.5	1.7	1.7
Species of limited occurrence or low palatability:						
Highbush cranberry, Viburnum trilobum	1.4	1.2	.8	1.2	.6	1.0
Northern white cedar, Thuja occidentalis	5.8	4.5	.7	1.6	.1	.4
Yellow birch, Betula lutea	.8	.3	.6	.2	.7	.7
Speckled alder, Alnus incana	3.2	3.3	.3	.7	.09	.2
White pine, Pinus strobus	.4	.6	.3	.5	.7	.8
Honeysuckle, Lonicera canadensis	7.8	4.5	.2	3.1	.03	.7
Red maple, Acer rubrum	.1	.3	.2	.4	2.0	1.3
Round leaf dogwood, Cornus rugosa	.1	-	.1	.1	1.0	-
Black ash, Fraxinus nigra	.4	-	.1	.1	.2	-
Black spruce, Picea mariana	.8	.6	.1	0	.1	0
Red-berried elder, Sambucus racemosa	1.4	1.6	.1	.5	.07	.3
Currant and gooseberry, Ribes spp.	.2	.3	Trace	.1	-	.3
White spruce, Picea glauca	2.2	-	Trace	-	-	-

1/ Percentage of available browse.
2/ Percentage of total browse use.
3/ Percentage of total use divided by percentage of available browse.

Species which were not fed upon, but which occurred in only very small quantities were:

Green ash, Fraxinus pennsylvanica var. lanceolata
Jack Pine, Pinus banksiana
Juniper, Juniperus communis var. depressa
Rose, Rosa sp.
Ninebark, Physocarpus opulifolius
Tamarack, Larix laricina

slightly less palatable than aspen and which recovers well from browsing, has maintained its position as to availability and use, and appears to be the mainstay of the moose herd at the present stage. Balsam, ranking well to the top in palatability, has shown increasing use. Because of its extremely low resistance to browsing, its place in the forest stands is being taken over by spruce (fig. 8). Mountain

Figure 8.--Under heavy use balsam may be killed out.

ash, with very high palatability was being overbrowsed (fig. 9). Red-osier dogwood, which recovers well from browsing, was slowly losing its position in both availability and use. Willow, another highly favored food, seemed to remain in about the same relative position. Many species intermediate in palatability or availability showed inconclusive trends. The greatest differences were with such species as white cedar, which was fairly high in availability but was little fed upon in 1945. By 1948 its use had more than doubled--an indicator of heavy overbrowsing on the island. Another very noticeable feature was that fewer species were receiving the bulk of the browsing in 1948. 13/

Where present, ground hemlock is a good indicator of moose browsing intensity. In the area studied it has been limited by heavy browsing to a few small plants, most of which would be covered by deep snow, thus accounting for its comparatively low palatability factor.

The palatability ratings given to the moose foods on the island by Hickie (1937) agree almost completely with those listed above. One exception is that Hickie considered honeysuckle a preferred food.

Figure 9.--Mountain ash heavily browsed by moose.

Manweiler (1941) in Minnesota added the following to the list of winter foods: chokecherry (Prunus sp.), basswood (Tilia americana), goldenrod (Solidago sp.), grasses, lichens (Thallophyta) and liverworts (Bryophyta). Seton (1929) considered striped maple, (Acer pennsylvanicum) a favorite winter food.

The stomach contents of a moose taken April 29 in Maine and analyzed by the Fish and Wildlife Service were composed of the following: Balsam, 45 percent; birch, 45 percent; maple, 1 percent; northern white cedar, 1 percent; sheep laurel (Kalmia angustifolia), trace; willow, trace.

Where a moose population of medium density was present in the Mt. Katahdin region of Maine, 7 species made up 99 percent of winter moose foods. These also accounted for 98 percent of the food available.

The following table shows the percentages of available browse species and percentages eaten. (Dyer 1948)

TABLE 3.--Availability and use of winter moose foods in 12 Maine yards.

Species	Percentage of available browse	Percentage of food eaten
Balsam	36.7	54
Mountain maple	22.2	23
Mountain ash	4.2	5.4
Paper birch	22.5	5.4
Striped maple	6.0	4.9
Fire cherry	4.5	5.1
Aspen	2.3	1.3
Withe rod	.3	.2
Beaked hazel	.6	.1
Red maple	.3	.2
Willows	.3	.4

Summer Foods

Summer foods do not appear to be as critical a factor in moose management as winter ones. Krefting 14/, working with 206 hundredth-acre plots on Isle Royale, found browsing on 19 woody plant species; the twelve top-ranking species made up 93 percent of the summer food. Feeding was limited to leaf stripping and the cutting of some branch tips. Table 4 summarizes the data from the summer browsing plots.

TABLE 4.--Comparison of availability and use of summer moose food in Isle Royale National Park

Species	Percentage of Availability	Percentage of use	Palatability factor 1/
Sugar maple, Acer saccharum	9.7	18.4	1.9
Mountain maple, Acer spicatum	15.4	15.5	1.0
Mountain ash, Sorbus americana	15.9	13.5	.8
Paper birch, Betula papyrifera	11.3	11.8	1.0
Aspen, Populus tremuloides	8.6	9.1	1.1
Willow, Salix spp.	7.6	7.5	1.0
Red-osier dogwood, Cornus stolonifera	4.4	3.9	.9
Fire cherry, Prunus pennsylvanica	5.7	3.8	.7
Yellow birch, Betula lutea	3.4	2.7	.8
Black ash, Fraxinus nigra	1.7	2.4	1.4
Hazelnut, Corylus cornuta	2.8	2.3	.8
Shadbush, Amelanchier bartramiana	2.1	2.1	1.0
Red-berried elder, Sambucus racemosa	3.3	1.9	.6
Speckled alder, Alnus incana	1.9	1.9	1.0
Round-leaved dogwood, Cornus rugosa	2.5	1.7	.7
Honeysuckle, Lonicera canadensis	1.1	.5	.5
Balsam poplar, Populus balsamifera	.7	.5	.7
Bush honeysuckle, Diervilla lonicera	.5	.3	.6
Mountain alder, Alnus crispa	1.0	.2	.2

1/ Factor secured by dividing percentage of use by that of availability.

The interesting thing about this summer feeding is the tendency toward equal palatability of many broadleaved species, and a lack of conifer use. Although sugar maple had the highest palatability factor, it was particularly abundant in the west end of the island where this study was made.

14/ Krefting, Laurits W. 1946 Isle Royale summer moose browse survey, 1946. Progress Report, Fish and Wildlife Service, pp. 1-12, (Not available for distribution).

In addition to woody plants, feeding was observed on jewelweed (Impatiens sp.), false Solomon's seal (Smilacina trifolia), and large-leaved aster (Aster macrophyllus). Feeding on jack-in-the-pulpit (Arisaema triphyllum) and wild lettuce (Lactuca canadensis) was reported.

At a time when moose were near a peak population on Isle Royale (probably five per square mile) Murie (1934) found that the salmonberry (Rubus parviflorus) was taken more in late May than during the summer. Ground hemlock was still present and a favored food. Rose (Rosa acicularis) was scarce but heavily browsed. He also found that ferns (Polypodiaceae or Osmundaceae), asters, sedges (Cyperaceae), and grasses (Gramineae) were taken in early summer while tender. Jewelweed was not taken until it was in bloom in August. In addition, the following were found to be eaten: Brake fern (Pteridium aquilinum), horsetails (Equisetum fluviatile), pondweeds (Najadaceae), sedges (Carex), rushes (Juncus), cowslip (Caltha palustris), purple rue (Thalictrum purpurascens), red clover (Trifolium pratense), violet (Viola spp.), fireweed (Epilobium spp.), cow parsnip (Heracleum lanatum), water hemlock (Cicuta bulbifera), swamp buttercup (Ranunculus septentrionalis), and turtlehead (Chelone glabra).

Moose become semi-aquatic in summer, normally feeding heavily on water plants. This type of vegetation largely disappeared on Isle Royale years ago. The buds and leaves of the water lily (Nymphaeaceae) are particularly relished and there are cases where large lily beds have lost every bud to feeding moose. The stems and roots are also eaten (Cahn 1937).

Western Range

Winter Foods

In the West, willows and moose are inseparable both in winter and summer (Murie 1944) (fig. 10); in fact, Cooney 4/ (1943) suggested that the intensity of willow browsing could be used as an index of moose populations. Buffalo berry (Shepherdia canadensis) is reported to be heavily browsed in Montana during fall. 7/ Other species high in palatability are Douglas fir (Pseudotsuga taxifolia), lodgepole pine (Pinus contorta), aspen and balsam. Alder and spruce were not readily taken.

In British Columbia the following species were considered the most palatable (Hatter 1946):

Red-osier dogwood, Cornus stolonifera
Paper birch, Betula papyrifera
Willow, Salix spp.
Aspen, Populus tremuloides
Mountain ash, Sorbus americana
Bog birch, Betula sp.
Shad bush, Amelanchier florida

Grand fir, Abies grandis
High-bush cranberry, Viburnum pauciflorum
Pachystima myrsinites
Acer douglasii
Equisetum sp.

Figure 10.--Willows are the key species on many western moose ranges.
Photo by Montana Fish and Game Commission

Summer Foods

Cooney 4/ reported Montana moose feeding in summer as follows:

TABLE 5.--Estimated average percentage of foods taken by Montana moose in summer and fall

Types of forage	June	July	August	September	October
	Percent	Percent	Percent	Percent	Percent
Shrubs	64	72	81	87	93
Grasslike plants	8	6	5	3	2
Grasses	12	8	4	3	1
Weeds	14	11	6	2	2
Underwater plants	2	3	4	5	2

In spring feeding is on the early, succulent plants; in June and July the animals wander, sampling almost any food plant in reach. Later the menu narrows down to browse and underwater plants. Alder is often untouched alongside heavily-used willows. Some of the important summer browse species besides willow are buffalo berry (Shepherdia), huckleberry (Vaccinium), bearberry (Arctostaphylos), honeysuckle, elder and some snowberry (Symphoricarpos).

Alaska

In Alaska, even more than in the western United States, willow is the important moose food. Dufresne (1942) estimates that the various willow species make possible an Alaskan moose range of 240,000 square miles. The narrow-leaved species are apparently preferred, 3/ however, several others less important are equally palatable and many kinds are taken.

Palmer 8/ prepared a table of palatability ratings based on observations made over a seven-year period (Table 6).

Other species available but which were refused or were taken only very rarely included devil's club, heather, squawberry (Menziesia), spirea, buffalo berry, Myrica gale, chaparral, bog rosemary, yarrow, Cicuta, monkshood, larkspur, loco, fern, club moss, hawksbeard, crowberry, shrubby cinquefoil, pyrola, fernweed, and marsh marigold.

TABLE 6.--Relative palatability of moose food species in Alaska

Species	Palatability
Tree birch	100
Ground birch	100
Willows	100
Mountain ash	100
Red currant	100
Black currant	100
Service berry	100
Aspen	75
Cottonwood	75
Elder	75
High-bush cranberry	75
Alder	50
Carex	50
Fescue	25
Marsh grass	25
Horsetail	25
Rush (Juncus)	20
Potamogeton	20
Bur-reed	20
Bunch grass, wheat grass (Agropyron), blue grass (Poa), and wood rush (Tuzula)	15
Lupine	15
Wild parsnip	15
Raspberry	15
Fireweed	10
Blueberry	10
Pond lily	5
Rye grass	5
Rose	2
Tea (Ledum)	2
Twin-flower	2
Cotton sedge	2
Lichens	2
Cranberry	2
Sphagnum	1
Polytrichum	1
Herbaceous dogwood	1
One-flowered pyrola	1

Winter Foods

In fall feeding was chiefly on willows and grasses; fescue, marsh grass, and woodrush were particularly relished.

Palmer described the winter food as mainly browse from willows, ground birch, and cottonwood, and from the green bases of bunch and marsh grasses. When food is scarce, the bark of aspen and willow is commonly taken. Occasional barking seems to be normal.

TABLE 7.--Stomach contents analysis of seven Alaskan moose taken in fall and winter 6,8/

Species	Average percentage of contents
Willow	45
Birch	31
Alder	6
Grass and sedge (mainly in 1 fall stomach)	5
Aspen	3
Lichens	1
Cranberry	Trace
Spruce	Do.
Horsetail	Do.
"Peavine"	Do.
Mosses and sphagnum	Do.
Undetermined	7

In late March and early April the moose paw through the snow to feed on lichens, ground birch, willow and the occasional green shoots of grass clumps in addition to the usual species browsed above the snow.

Summer Foods

The foods taken in spring include the succulent growth of grasses and willow shoots. The cows seek variety, taking anything green or succulent. As soon as new growth starts on the wet flats, south slopes, and in swamps, the moose feed heavily on grasses, sedges, horsetails, and wild parsnip. In a number of cases recorded by Palmer 3,6,8/, the animals pawed the thin soil away and fed on the outer bark of aspen roots.

Feeding is concentrated especially on willows, mountain ash, highbush cranberry, aspen, birch, ground birch, cottonwood, and elder in summer. Foods taken in lesser quantity include red currant, alder, blueberry, the tops of fireweed and lupine and occasionally Labrador tea. In swamps, cotton sedge, and Carex were fed upon while in ponds and lakes stalks of pond lily, bases of rushes (Juncus), bur-reed, horsetails, and pondweed were included.3/

Licks

Licks are commonly reported from Alaska to the northeastern United States. These vary widely in size and type, but most writers agree that they are areas of concentration of mineral salts.

Surber (1940) reports one case from Minnesota where the black soil was eaten away to gravel at a depth of approximately three feet over an area about 100 feet by 75 feet. The trails leading to it were worn down 3 feet deep near the lick and could be traced back over the ridges. On the Kenai Peninsula of Alaska a lick is described by Shiras (1912) as a "big, bare field" eaten down several feet below the surrounding levels. An analysis showed "strong" concentrations of sodium and chlorine, "marked" amounts of iron and aluminum, a "decided" fraction of calcium and magnesium, with sulphuric acid, phosphoric acid and sulphides present. A large part of the concentration occurred as common salt.

Dufresne 5/ reports that the licks in Alaska are used by bulls, cows, and yearlings and that they are visited most often when the animals are feeding on green grass and soft, shrubby growth. Use of the licks decreases by mid-August. 3/

On Isle Royale the licks were observed along streams or in swamps and were ordinarily muddy and full of standing water. The animals usually sipped the water, but mud was also taken (Murie 1934). The roots of trees were undermined in places by the eating away of the mud. Up to 20 moose were seen at a lick at one time. It was reported that these licks were used even in winter. An analysis was made of four samples of the water from licks and one sample of soil extract. Salt content ranged from .10 to .25 percent, and all samples contained calcium, iron, magnesium sulphates, and sodium chloride. Some licks were used also as wallows.

Dixon (1939) reports that in the Mt. McKinley National Park, Alaska, mineral springs are visited by the moose particularly in late spring and early summer.

Cover

The moose is usually found in woodlands or brushy areas, thus its needs for cover are well provided. It makes good use of conifers as a place of concealment, a fact well shown in an airplane count made on Isle Royale, as reported in 1946 by Karl T. Gilbert of the Park staff. On two occasions moose seen in the open became frightened and went into coniferous cover where they could not be seen even though the plane circled over the spot several times. Penned animals in Maine were found to seek the protection of thick, evergreen cover during heavy rains (Lamson 1941).

The animals rest in all sorts of cover from poplar stands to swales (Murie 1934). A large bull was observed in Wyoming lying in a thicket of head-high willows in a river bottom.

Moose-Beaver Relationships

Beaver affect moose range both favorably and adversely. By damming streams and flooding areas which fill in with sediment and tend to become marshy, the growth of favored foods such as aquatics and willows is encouraged. 2,4/ The ponds resulting from beaver activity are used to escape insects. On the other hand, by flooding large areas of poplar and other good moose foods, the food supply may be greatly reduced by a heavy beaver population, but at the same time, beaver cuttings along the shore make the tops and bark of older stands available to moose. Where moose browsing is heavy, aspen reproduction is retarded or prevented thus eliminating future food supplies for the beavers. 15/

Decimating Factors

Diseases and parasites

It is generally accepted that disease is an important factor in the decrease of moose in the Northeastern States. Dead moose were found in Minnesota as early as 1912. The nature of the disease or diseases is still not agreed upon. Common symptoms are that the animals become tame often staying close to buildings or open land and following people; emaciation is typical and blindness common. The animals sometimes travel in circles, and many of them are tick infested (Dermacentor albipictus). Studies in Montana give no indication of disease. 4/ McCabe and McCabe (1928) did not consider disease an important factor in British Columbia moose populations, however, by 1946 several dead moose were found and a respiratory disease was reported as well as heavy tick infestations (Hatter 1946).

Research workers (Wallace, et al. 1932; Cahn, et al. 1932) reported the finding in smears from the intestines of ticks engorged on diseased moose of a bacterium-like organism, which was named Klebsiella paralytica. The culture injected into guinea pigs and rabbits caused death within 8 hours. Seven years later, King (1939) expressed the opinion that this organism had not been confirmed as the causative agent of moose disease. Since the incidence of the disease was high, he thought the moose losses must be caused either by an infection or by a common environmental factor, such as a dietary deficiency or a toxic substance. Fenstermacher (1934) and his associates also were unable to obtain the same results as Cahn and his group. After some ten years' experience and autopsies on many animals, Fenstermacher and Olsen (1943) decided that there was no single specific cause of moose disease, but that the animals were susceptible to many diseases and parasites. Among these are ticks--the moose is a preferred host for D. albipictus; lungworms (Dictyocaulus hadweni); immature stages of tapeworm (Cysticercus tenuicollis) in the liver, muscles, and heart; Bang's disease; and brain disorders.

15/ Gensch, Robert H. 1946 Observations on the beaver of Isle Royale National Park, Michigan, from May 8 to June 4, 1946. Progress Report, Fish and Wildlife Service, pp. 1-18 (Not available for distribution).

Working with 20 animals in Maine, Lamson (1941) concluded that losses were due either to an obscure, undetected pathogen or to a combination of factors, which lowered resistance and made the animals susceptible to infections. Feeding experiments with penned animals indicated that nutritional deficiencies might be a cause of losses.

Murie (1934) found that necrotic stomatitis was common in Isle Royale moose.

Hatter (1946) reported the following parasites were found in British Columbia; tapeworm (Moneizia), hydatid cysts of Echinococcus granulosus, and a leg-worm Onchocerca cervipedis. He thought the only genus likely to be important was Echinococcus.

Predation

Wolves unquestionably kill some moose, but this seems to occur in the case of the adults only when they are at a disadvantage. Murie (1944) describes the attack of five Alaskan wolves on a bull moose. Although he lost a prong from one horn, there were no signs of blood on the ground and the wolves gave up the battle. In the same region a cow was observed with her hind legs apparently wounded by wolves, but she still had a calf with her. In the Liard River country of northwest Canada, MacFarlane (1905) found a patch of hard-packed snow where a moose had been killed by a pack of wolves; but one of the wolves was left behind with a broken leg. Another instance is described from British Columbia of a large, male wolf, with his legs and ribs broken, left at the scene of a battle with a moose (Stanwell-Fletcher 1942). The same author reported that wolves frequented moose "yards" in December, but so long as the snow was shallow, the hoofs of the moose were more than a match for the wolves. Later, when the snow depths reached 6 to 8 feet, and snowshoe hares, grouse, and ptarmigan became difficult to catch, the wolves, traveling in packs of 30 or more animals, turned to moose hunting. In the winter of 1938-39, seven moose were killed in an area of five square miles. Olson (1938) found that with a population of one wolf to ten square miles, eight deer per square mile and one moose to $2\frac{1}{2}$ square miles; deer instead of moose were taken by the wolves. In Alaska, Dufresne (1946) observed that wolf packs killed many moose during periods of deep snow.

Cowan (1947) discovered that the question of wolf predation on the big game of the Canadian National Parks in the Rocky Mountains was rather involved. The wolf populations were estimated to be 1 animal in 87 to 111 square miles of potential range, and 1 to 10 square miles of late winter range, with no appreciable change in numbers during a four year period. There were 300 to 400 head of big game to each wolf, and elk numbers were estimated to be 50 percent above carrying capacity of the range. Cowan learned that a lone wolf was capable of pulling down and killing moose or elk in summer. Although he checked the running speed of moose at 27 miles an hour, elk at 28 to 29, and buck mule deer at 30, the wolf seldom

exceeded 25 miles per hour. Moose usually took to water when pursued and the wolves would not follow. In one instance in November a moose beat off three wolves, which left and soon after killed a deer. The wolves were often at a disadvantage when attempting to attack moose in soft snow, but the advantage was with the wolves if a crust formed over snow 1½ feet or more deep.

Analysis of feeding habits of the wolves show a marked variation in the use of big game species. The following table contrasts use by wolves with abundance in percent of the various species.

TABLE 8.--Comparison of abundance of big game species and their occurrence in wolf scats in certain Canadian National Parks

Species	Percentage of relative abundance of prey species	Percentage of occurrance in scats		
		Summer	Winter	Annual
Elk	33	49	42	47
Mule deer	11	15	14	15
Moose	4	9	4	7
Bighorn	42	6	8	7
Caribou	1	5	0.5	3
Goat	9	0.5	0	0.5

Summer feeding on moose was limited to calves, as was also more than half of the winter feeding. Because of the fact that moose calves probably suffer more from accidents than the young of any other species of our big game; the predation on moose was thought to be unimportant. Support for this belief comes from the fact that there was no significant difference in survival of calves to one year of age on wolf-free and wolf-inhabited ranges. Condition of the range was much more of a limiting factor.

Seton (1929) tells a very interesting story of a December struggle in deep snow in New Brunswick between two bears and two bull moose. After two battles one bear was found dying from a horn-thrust in the abdomen and the other was treed; the moose apparently were able to retire in good order.

With a large bear population, however, moose calves suffer. In the Kenai Peninsula, Alaska, the population of both black and brown bears has been building up in recent years. Prior to 1934, black bears were not protected and many were killed for fox feed; in two seasons over 200 were taken in one drainage alone. Dufresne 5/ stated that the black bear seldom preyed on moose calves at that time, however, moose of all classes respected the big brown bears. With protection the increase of bears was rapid, and in 1938, Palmer estimated that there were 20 times as many as in 1890. It was observed that the moose were not shy in the spring until the bears came out

of hibernation in early May. Then the moose would dash off whenever a man was seen in the distance. 8/ It was also noted that whenever a black or brown bear appeared the moose would "evacuate the area in no hesitant fashion". Up until calving began, he reported, the black bears ate mainly vegetation, carrion, ants, and grubs; but during the calving season 12 of 39 black bear stomachs examined contained calf moose remains. The 5 to 8 weeks before the first salmon run in July was the period in which the calves suffered most. At this time most of the brownies were in the high country off the main calving range; also the blacks preferred fresh meat while the brownie preferred carrion. The black was accordingly rated as the chief predator in the area. Twin calves were seen frequently in 1939 until mid-June, after which they decreased, and of 86 cows observed but 26 were accompanied by yearlings, indicating a calf survival of only 30 percent. The absence of calves had been particularly noticeable the previous 5 or 6 years. 6/ In 1944, according to Sarber (1944), both brown and black bears were killing so many of the calves that by September only one calf was observed with a total of 93 cows. This occurred on an area of 150 square miles in which there were an estimated 250 to 300 moose and 100 to 150 bears (10 black to 1 brown). Here few adult moose were killed even by the brown bears. The bears are also rated as highly destructive to moose calves in the Yukon flats (Dufresne 1946). In Montana, also, the bears are rated the most common moose predator. 4/ Nevertheless, it was felt that predation was unimportant here. 7/

In the Jasper National Park, Alberta, unlike those of the other Canadian Parks in the Rocky Mountain area, the grizzlies subsisted largely on elk and moose which they ran down and killed (Cowan 1947).

The coyote is apparently ineffective in killing moose. Even in snow 4 to 5 feet deep on Isle Royale, coyotes would tire out the moose, but when they turned on their pursuers, the snow was soon trampled enough to give a firm footing and the coyotes forced to retreat (Hickie, undated). On Isle Royale the moose have built up a heavy population, while the coyotes as well as snowshoe hares and other small mammals are scarce. The studies in Montana showed no evidence of coyote predation on moose calves. 4/ In Jasper National Park, it was found that carrion from both adult and calf moose occurred in 5 to 10 percent of coyote scats. While the grizzly bear was thought to kill the adult moose, calves "not infrequently" drowned while attempting to follow their mothers across difficult bodies of water. This was considered to be the source of the calf moose carrion (Hatter 1945). In Alaska the coyote was considered to have little or no effect on moose. 5,6/ The coyote tends to keep the snowshoe hare populations low thus protecting the moose food supply (Murie 1934).

There is some evidence that the cougar can kill moose (Young and Goldman 1946), but with their present numbers over range in the United States, they would certainly be a negligible factor.

Drowning

In Alaska many moose lose their lives while the ice is thin on lake outlets, rivers, and creeks. Palmer writes of the finding of 27 carcasses one spring in a distance of 3 or 4 miles in the slackwater of the Kasilof River. 6/ The same condition was found in British Columbia (Hatter 1946).

Winter Kill

It has been found in Alaska that with 3 to 4 feet of snow few moose die unless a crust forms. In 1923-24, when a deep snow crusted, over 107 carcasses were counted along 3 miles of the trail down to a beach. 6/

MANAGEMENT

Census Methods

Over most of its range the moose is a very difficult animal to count. Airplane counts of the ones observed on sample strips of a given width have been used to estimate the population of Isle Royale National Park. It seemed certain that many animals were missed, as only a few were located in the conifers; while big areas with coniferous cover had tracks in them, but the moose were out of sight. Best results could be obtained on a day with new snow and high clouds, when there were fewer tracks and no deep shadows. 10/ In Montana, where feeding areas were localized and visibility good, a useful, general method used in counting was to locate these areas and wait for the animals to come out to feed. 4/ June was considered the best month for counting, since both bulls and cows with some early calves were then on the open slopes throughout the day feeding on succulent plants. September was the second best month for counting. 7/

Body proportions, color changes, and molts offer means of determining sex and age. The bulls are more stocky and heavier in the shoulders than the cows.

On the Kenai range the newborn calves were reddish. The yearlings were almost black with the hind legs, and sometimes all four legs, whitish. The adult cows are more reddish and the bulls more smoky or with a slaty tinge. 6,8/ Cows with calves are the last to molt; some have been seen still with winter hair in mid-July. 5/

A limited number of calves have been tagged to aid in studying movements, populations, and life histories. Under Montana conditions it was found that very young calves could be tagged by two horsemen, working together. One horseman led the cow away by letting her repeatedly charge the horse. Then, when the cow was at a safe distance, the other rider dismounted and tagged the calf. This method is useable only on solid ground where the moose cannot overtake the horse. 9/

Individual adult animals can usually be identified by the characteristics of the antlers or of the bell or dewlap under the throat. 4/

Protection and Control of Kill

The history of the handling of moose herds in the United States has been mainly that of greater restrictions on hunting, then total closure of hunting seasons, and herds which have continued barely to hold their own or to dwindle. It is only recently that any promise has been seen that herds were building up.

Certainly closed seasons alone do not necessarily result in increases of moose. After 18 years of closed seasons, it was estimated that there were fewer moose in Minnesota in 1940, than when hunting was first prohibited (Surber 1940). To bring back the moose in the State, Manweiler (1941) suggested freeing large areas of submarginal land of homesteaders and squatters, plugging drainage ditches, damming bogs that dry out in summer, dynamiting wallowing places in bogs, establishing small refuges, and intensive patrolling.

Alaskan customs and tastes have presented a series of special moose protection problems. A general local opinion that a moose cow is much better food than a bull led to considerable illegal killing of the cows. Also, the Indian squaws prefer the leather made from the hide of unborn moose calves for baby clothes, and the meat of the calves is considered an invaluable aid when eaten during pregnancy. 8/

As the result of protection an overpopulation of moose had built up in the Absaroka National Forest, Montana, by 1943 (population estimated at 25 in 1921 and 308 in 1933). A herd classification in the primitive area of the forest showed 97 bulls to 67 cows. Because of this unbalanced sex ratio, it was recommended that 30 mature bulls should be killed to reduce the herd and then only a number equal to one-half the yearlings be killed under special permits drawn by lot each year. 4/ Such controlled hunting is a most useful tool in managing the herds to prevent overpopulations or overshooting.

Range Improvement

Where moose populations are so high, that food conditions are likely to be a limiting factor, browse surveys are a useful management tool. As soon as the browse shows overuse, the herd should be reduced to again bring it in balance with its food supply (Aldous 1944a; Aldous and Krefting 1946).

There is little available moose food on a range made up of old, dense stands of timber. Cuttings can be used to increase the available browse, both woody and herbaceous. These cuttings should be scattered and continuing rather than over big areas at one time.

It was found that climax forests below timberline offer practically no food for moose in Alaska. Fire results in sub-climax vegetation and makes the presence of moose possible. Willows are a main sub-climax dominant following fire as are also aspen, birch, ground birch, elder, mountain ash, and high-bush cranberry. A fire in the Kenai Peninsula about 1880 destroyed the lichens and undoubtedly caused the disappearance of the caribou; but moose appeared about 15 years later, and were abundant 30 years after the fire. Reestablishment of the climax forest was relatively slow; and fifty years following the fire of 1880, it was thought that another burning would likely reduce rather than increase the forage as establishment of new cover would require a good many years. It was estimated that the area would be good moose range for another 25 years, when it might need re-burning or, better, cutting. 2,3/ Hatter (1946) has recommended controlled burning for British Columbia moose ranges.

Where fires kill the big trees in old woods, more browse is often the result for a period of years. However, the typical forest soils of the northern States are shallow and have a high organic matter content. While the first fire to burn through the old growth may remove only an inch or two of the organic layer, a second fire usually goes much deeper leaving the soil distinctly impoverished. In short, fires do nothing for the moose browse supply that properly-regulated cuttings cannot do better and without the accompanying soil deterioration resulting from repeated or heavy fires.

In areas where water conditions are suitable, the planting of aquatic plants, such as wild rice, had been suggested for improving the moose food supply. 2/

Carrying Capacity

Palmer found that the Alaskan moose range was being fully utilized when the willows, mountain ash, elder, high-bush cranberry, aspen, birch and cottonwood were held to heights of 2 or 3 feet. Browsing back of the willows increased summer food but decreased that available in winter. Even the closely cropped willows produced seed. Summer forage was abundant, but the winter supply was more critical and management had to be based on winter use. The lower slopes and drainage bottoms received the deepest snows, consequently the upper benches and ridges received most of the browsing during severe winters. It was estimated that the carrying capacity of the Kenai range was a moose to 245 acres. 3/

Productivity

The only available figures on moose production in a definite area come from the Kenai Peninsula, Alaska. Here, a herd of 1,000 containing 800 cows was estimated to produce a 30 percent calf crop. Assuming a 50:50 sex ratio and normal losses after the yearling stage, this herd would produce a harvestable crop of 216 cows and bulls. Maintenance of a 4:1 sex ratio would necessitate the killing of both cows and bulls. 2/

Sanctuaries

The role of sanctuaries in moose management is difficult to evaluate. In some instances state-wide protection has failed to build up the moose population; in a few others refuges have been successful.

Isle Royale National Park, an island area of about 212 square miles, has had a unique history as a moose sanctuary. It is 13 miles from the Canadian shore at the closest point, and Lake Superior seldom freezes solidly between it and the mainland. Ecologically, it is a typical northern forest island on which the old growth was mainly balsam, white and black spruce, northern white cedar, hard maple, paper and yellow birch, and aspen. Copper mines were opened on the island in the period around 1843-1855 and again in the 1870's, and extensive fires occurred during this mining period. In 1936 a fire covered about one-fourth of the island. The only timber cutting occurred in 1935 when 2,500 acres were cleared.

Caribou were evidently the important original big game of the island; however, there seems to be little evidence that they were abundant here in recent times. They disappeared about 1925.

Records in the files of the National Park Service indicate that moose were very scarce on Isle Royale in 1880. Adams (1909), making an ecological survey of the island in 1905 saw no moose; however, a member of his party saw evidence of browsing which was typical of moose. During the winter of 1912-13 the water froze from the island to the mainland and moose were seen on Isle Royale the next summer. The numbers increased rapidly and by 1921-22 about 1,000 animals were estimated present. By the fall of 1931 Stephenson (1931) found an "extremely plentiful stocking" of moose, and a browse line wherever he went about the island. He reported that there was no recent reproduction of favored, woody food plants. Murie (1934) estimated the population in 1930 as at least 1,000 and possibly 3,000. A die-off came between 1932 and 1934 and an estimated 200 were left (Aldous and Krefting 1946). Since then the animals have been increasing and aerial counts gave an estimated population of 510 in February 1945 and 614 in February 1947. 10/

Some very interesting ecological changes have been caused by the heavy population of moose. The survey notes of William Ives in the Isle Royale National Park files provide valuable data on the vegetative conditions in 1847. He described not only the tree species along each

survey line, but also the shrubby growth. His record of 1,578 witness trees showed the following distribution by species:

Species	Percent
Balsam	40
Northern White cedar	22
Spruce	16
Paper birch	8
Yellow birch	6
Tamarack	5
Hard maple	2
Aspen	1
White pine	-
Balsam poplar	-

With the possible exception of the short-lived aspen, choice of these trees as markers should have been representative of their distribution in the stands.

General descriptions were written for each of 72 sections surveyed. Ground hemlock was recorded for 56 percent of them, spotted maple (Acer spicatum), 60 percent, hazel, 46 percent, and alder, 18 percent. As late as 1905 Adams (1909) wrote of ground hemlock, ".....everywhere abundant in the upland forests of the island. On account of its low spreading growth it forms one of the greatest impediments in penetrating the island forests." This could well describe some of the moose-free outlying islands at present, but on Isle Royale itself this highly favored food has been practically eliminated. It is very unusual to find one of these plants alive above the winter snow line.

The moose eat spruce only as a last resort and regularly consume balsam to the point of eliminating young stands by the acre, thus the balance is being thrown continually in the direction of spruce dominance over balsam and the food production of the range decreased accordingly.

St. Ignace Island, farther up the northern shore of Lake Superior in the Province of Ontario, has had a somewhat similar history. Although it is possible for moose to reach the mainland by crossing only about a mile of water, there still have been die-offs. In 1917 it was estimated that there were about 10 moose to the square mile, and spruce was the only living upland vegetation that had not been browsed to a height of twelve feet. Also, aquatic plants were eliminated to about ten foot water depths. The following winter a big die-off occurred (Shiras 1923). The herd has built up again, but the amount of browsing indicates a lower population than on Isle Royale.

These two islands illustrate special cases where the animals are not able to migrate easily. Whether similar ecological conditions have commonly occurred over larger ranges is questionable.

Stocking

Stocking of moose in favorable habitats has been tried in a few cases. In Newfoundland where the moose and white-tailed deer were not native, but caribou were present; a pair of moose is supposed to have been liberated about 1878. In 1904 two cows and two bulls were stocked. It was reported in the late 1920's by the Secretary of the Game and Inland Fisheries Board that the moose should total more than 2,000 (Seton 1929). John Pearce, who made a survey of Newfoundland conditions for deer in 1941, wrote that he believed close to 2,000 moose were present. They were well enough established that 17 and 40 were killed in 1939 and 1940, respectively, showing that the planting was a success (Harold S. Peters, letter).

Twenty moose were released on Anticosti Island in the Gulf of St. Lawrence about 1900. Estimates placed the number at about 250 in 1937, but the population showed no signs of building up very high (Newsom 1937b). This was in an area with a deer population in 1936 of about one to forty acres.

Probably the largest stocking of moose carried out in this country was with animals trapped on Isle Royale. A total of 69 of these was released at 3 points in the Upper Peninsula of Michigan during the winters of 1934-35 to 1936-37 (Hickie undated). By 1937, 88 animals were reported, of which 20 were calves, and the project looked promising; however, only 54 (11 calves) remained in 1938, and by 1940 only 8 (2 calves) were reported. Some animals were found shot, and a few were known to have died from accidents, but the great majority were unaccounted for (Titus 1941).

CONCLUSIONS

We still have much to learn about the life history and management of the moose. However, with closed seasons, herds have built up in some parts of the country to the point where they are being managed with limited hunting. In other places the herds seem to be approaching this point. The experience gained from the management that has been carried out indicates the necessity for certain preliminary measures.

A reliable inventory is one of the most valuable sources of information needed for the management of a moose herd. It should show sex ratios and make an age classification. These data indicate the potential rate of increase and calf survival, and help determine whether hunting is justifiable and, if so, how many animals should be taken.

Where large local populations have built up, browse surveys can be used to determine if the species is reaching the carrying capacity of the range.

Due to the great value placed on the moose as a trophy and a source of meat, and to the ease with which it may be taken after long periods of protection, the kill in a given herd should be held to a definite number based on inventories. Otherwise the numbers may be reduced to a point so low that it will take many years for a satisfactory population to build up again.

Controlled hunts, removing only definite portions of individual herds, is the best method so far found for regulating moose numbers. State-wide open seasons with no control of the kill are likely to cause such great population reductions that decades would be required to reach the point where hunting again could be justified.

It has been shown, both in the United States and Alaska, that old forests produce little browse available to moose. Cuttings in these stands result in greatly increased and more desirable forage. These cuttings should be scattered and continuing rather than over big areas at one time.

While applying these preliminary management measures, thorough studies of the moose should be carried on in the major geographic regions where they are still found. Certainly it would be a catastrophe to lose this valuable animal because we had not learned how to manage it.

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